

SUSTAINABILITY OF ENERGY EFFICIENCY AND ENERGY SECURITY FOR AIRPORTS IN SOUTH AFRICA: GUIDELINES FOR ADOPTING GREEN BUILDING STATUS FOR NEW INFRASTRUCTURE

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ABSTRACT

Executing projects that save energy through efficiency and conservation for a site and adopting alternative energy to reduce its carbon footprint can assist in abating climate change. However, with time, new infrastructure will be adopted either through expansion or refurbishments that could threaten to negate the efforts of previous projects in reducing carbon emissions. The adoption of “green buildings” that are compliant with environmental requirements including reduction in carbon emissions and energy consumption will serve to ensure that previous efforts towards reduced carbon emissions are sustained. In South Africa, the Green Building Council of South Africa has green star rating frameworks and accreditation for new infrastructure. This paper presents the guidelines for adopting green star rated infrastructure at airports in South Africa in order to sustain energy efficiency and energy security for new terminal, office and commercial buildings in compliance with the green star rating system of the Green Building Council of South Africa.

KEYWORDS: *Energy Efficiency, Energy Security, Green Buildings, Environmentally Sustainable Buildings, Environmental Responsibility & Resource Efficiency*

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1. INTRODUCTION

Reducing carbon emissions in any organisation requires a lot of effort and involves a change in thinking when satisfying business needs, putting in place strategies and creating a culture of doing business that reduces carbon emissions. Ensuring that this culture of reduced carbon emissions is sustained requires adoption of relevant standards at an early stage so that changes that occur with the passing of time and changes in personnel, strategies, commercial markets and products as well as construction of new infrastructure do not undermine the initial gains. Airports Company South Africa (ACSA) has an ambition to reduce carbon emissions across its airports in South Africa and has put in place an energy and demand management strategy, approved a suite of technologies to reduce carbon emissions, and adopted standards and guidelines for energy efficiency.

ACSA owns and operates nine airports in South Africa, namely, O R Tambo International Airport (ORTIA) (Kempton Park, Gauteng), Cape Town International Airport (CTIA) (Western Cape), King Shaka International Airport (KSIA) (Durban, KwaZulu-Natal), Port Elizabeth International Airport (PEIA) (Eastern Cape), East London Airport (Eastern Cape), Bram Fischer International Airport (BFIA) (Bloemfontein, Free State), George Airport (Eastern Cape), Upington International Airport (Northern Cape) and Kimberley Airport (Northern Cape). ACSA's energy and demand management strategy aims to make ACSA a recognised leader in the implementation of energy solutions that are economically and environmentally sustainable for airport businesses. This strategy is in line with ACSA's vision of being "... the most sought-after partner in the world for the provision

of sustainable airport management solutions.”

At its core, ACSA’s energy and demand management strategy intends to reach carbon neutrality in electricity consumption by 2030. The three strategic objectives to support the strategy are: (1) reduce energy consumption to drive carbon neutrality, (2) introduce an energy mix that is responsive to the ACSA business and operating environment, and (3) drive an energy efficiency culture within ACSA through accountability, standardisation and a structured approach to managing energy intensive infrastructure. These strategic objectives have been translated into executable projects and initiatives that have been included in each of ACSA’s nine airports’ roadmaps to carbon neutrality. Significant progress has been made to reduce energy consumption and plans are in process to realise a low carbon energy mix at the airports. The low carbon energy mix transitions the airports’ current electricity demand towards carbon neutrality and makes provision for future energy demand. However, to ensure that energy wastage and practices that negate efforts to drive carbon neutrality are mitigated when new infrastructure is introduced, standards must be adopted. To bring about a culture of energy efficiency, standardisation and a structured approach to managing energy intensive infrastructure, there must be adherence to green buildings design for all new infrastructure to ensure that environmentally sustainable decisions are implemented.

Green buildings incorporate design, construction and operational practices that significantly reduce or eliminate the negative impact of development on the environment and people. Green buildings are:

- Energy efficient,
- Resource efficient,
- Environmentally responsible,
- Healthy and productive environments for people.

In short, a green buildings approach will ensure that whatever the development (whether office, terminal building, commercial building, etc.) the aim will be to reduce demand and impact on the environment and health of humans. This approach entails rainwater harvesting, onsite processing of waste into useful products, generation of energy, reducing energy and water consumption, using recycled building materials and materials low in greenhouse gas emissions, better air quality, etc.

The Green Building Council of South Africa (GBCSA) has been set up to certify infrastructure such as office buildings, retail centres, public and education buildings, and precincts, according to a green star rating framework, namely, 4-star, 5-star and 6-star rated. The GBCSA is an independent, non-profit member-based company that was formed in 2007 to lead the greening of South Africa’s commercial property sector. GBCSA provides the tools, training, knowledge, connections and networks, to promote green building practices across the country and build a national movement that aims to change the way the world is built. There are over 98 individual and recognised green building councils worldwide whose mission is to abate climate change through green building. The World Green Building Council is an umbrella organisation that gives guidance to the different green building councils, of which the GBCSA is a member alongside Australia, the United States and the United Kingdom amongst others. The Green Building Council of South Africa has adopted, adapted, and contextualised the Green Star rating system. Originally developed by the Green Building Council of Australia, that rating system was used as a base and has been significantly modified to fit the local market and environmental context [1].

The GBCSA started off with green star rating tools for residential, office, public and education buildings, retail developments and existing buildings, as well as interiors of developments. Their tools have extended to rating sustainable precincts, net zero (carbon, water, waste, ecology), energy and water performance. and more in order to meet the South African market demand. There have been over 400 green star certifications between 2007 and 2018 in South Africa [1].

Certifying new airport buildings will serve to independently verify the airports' achievements and recognition as a leader in environmentally sustainable solutions for airport businesses. This paper describes the green star rating frameworks of the GBCSA, the structure of the technical manuals for the implementation of green star rated buildings for new infrastructure at airports, the rationale applied when selecting credits to make up the green star rating of new airport infrastructure, the key technologies, design features, standards for compliance, construction and project requirements for airports' green star rating, and the process to implement green star rated buildings for new airport infrastructure.

2. GREEN STAR RATING FRAMEWORKS DESCRIPTION

Green Star SA has established a number of categories under which specific key criteria are grouped and assessed. This framework is used by the Green Star SA rating tool. The basic Green Star SA structure is shown in Fig. 1 [2]

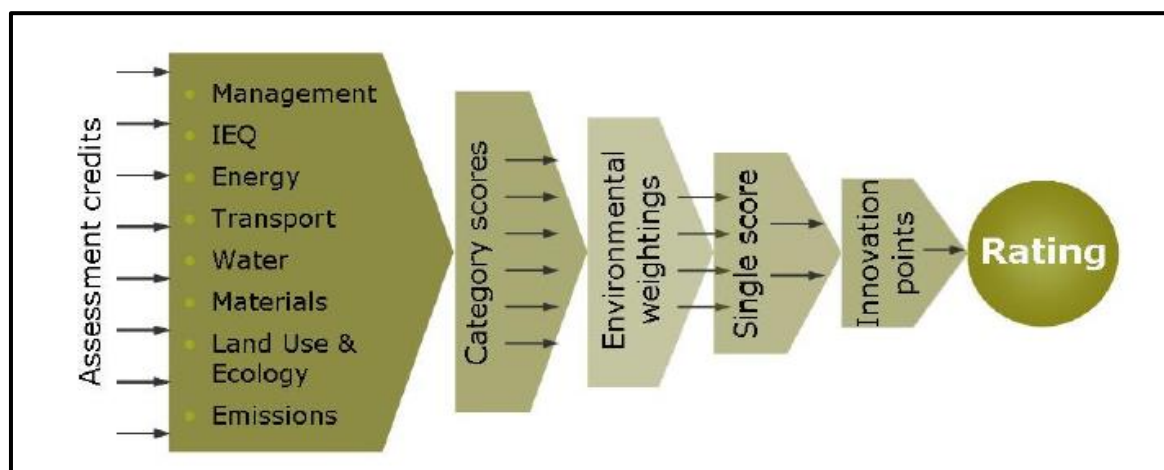


Figure 1: Structure of the Green Star SA Rating System [2].

Green Star SA rating tools include nine separate environmental impact categories:

- **Management** - promote the adoption of environmental principles from project inception, design and construction phases, to commissioning, tuning and operation of the building and its systems;
- **Indoor Environment Quality** - target the wellbeing of the occupants through addressing the heating and cooling systems, lighting, indoor air pollutants and some building attributes which contribute to a healthier indoor environment quality;
- **Energy** - target an overall reduction in energy consumption and a reduction of greenhouse gas (GHG) emissions associated with energy generation from fossil fuels;
- **Transport** - reward the reduction in automotive commuting by simultaneously discouraging it and encouraging use of alternative transportation;
- **Water** - address the reduction of potable water use through design of water efficient systems, rainwater collection

and water re-use;

- **Materials** - target the consumption of resources through selection and reuse of materials, and efficient management practices;
- **Land Use and Ecology** - promote initiatives to improve or reduce impacts on ecological systems and biodiversity;
- **Emissions** - target the environmental impacts of a development's emissions or substances emitted from the site (excluding greenhouse gas emissions which are dealt with in the energy category); and
- **Innovation** - encourage, recognise and reward the spread of innovative technologies, designs and processes for commercial building applications that impact upon environmental performance.

The categories contain credits which addresses specific initiatives that improve or have the potential to improve a design, project or building's environmental performance. Points are awarded in each category for actions that demonstrate that the project has met the overall objectives of Green Star SA and the specific aims of the Green Star SA rating tool. Green Star SA environmental weighting factors vary across rating tools to reflect differing environmental concerns and imperatives for different building types and lifecycle phases. To encourage the development and spread of innovative technologies, designs and processes that can improve buildings' environmental performance, an 'Innovation' category is included in each Green Star SA rating tool. Table 1 [2] contains the overall score and corresponding green star rating according to the green star rating system. [2]

Table 1: Green Star Rating SA Tool Scores

Overall Score	Rating	Outcome
10-19	1 Star	Not eligible for formal certification
20-29	2 Stars	Not eligible for formal certification
30-44	3 Stars	Not eligible for formal certification
45-59	4 Stars	Eligible for 4-Star Certified Rating that recognises/rewards 'Best Practice'
60-74	5 Stars	Eligible for 5-Star Certified Rating that recognises/rewards 'South Africa Excellence'
75+	6 Stars	Eligible for 6-Star Certified Rating that recognises/rewards 'World Leadership'

The certification process for a green star rating is extremely specific in terms of timing, documentation to prove criteria for each credit met as well as eligibility for the registration of a project to be certified. The process for certification is as illustrated in figure 2. If the project submission does not receive a rating in the first round, it is given a chance to submit outstanding or supplementary documentation in a second round to achieve a green star rating.

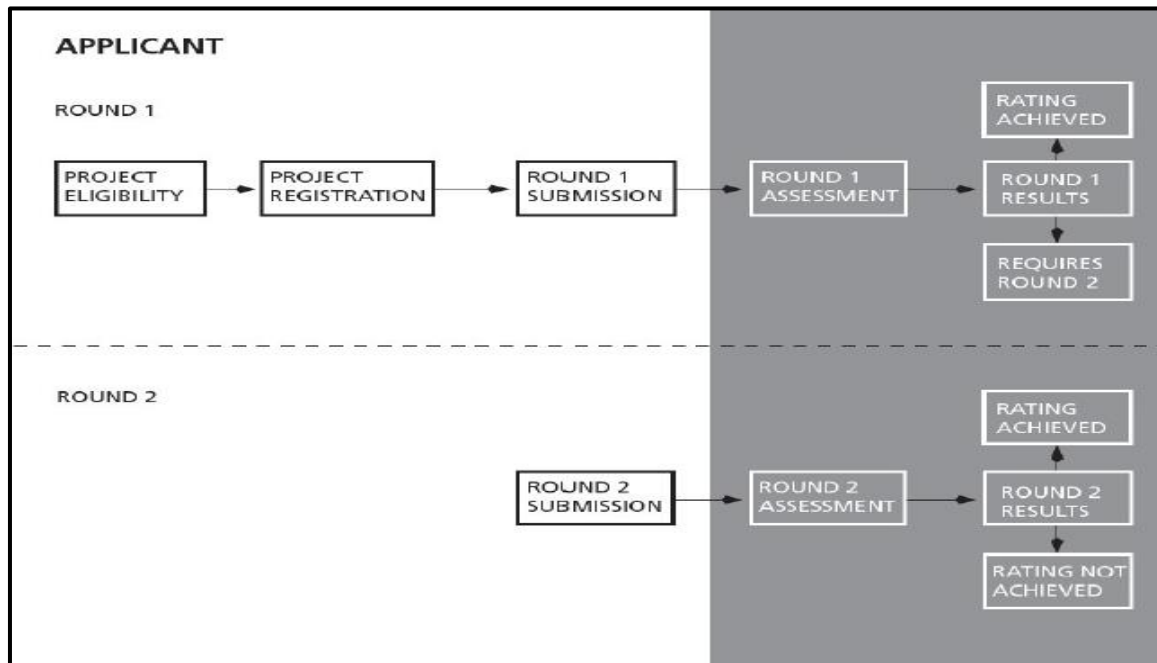


Figure 2: Overview of GBCSA Green Star Certification Process [2].

The following sections contain the structure of the technical manuals drafted for new airport infrastructure in the form of project specifications to be easily included in the design, construction, commissioning, and certification of new airport infrastructure in compliance with the specifications of the frameworks of the green star ratings of the GBCSA.

3. STRUCTURE OF THE TECHNICAL MANUALS FOR THE IMPLEMENTATION OF GREEN STAR RATED BUILDINGS FOR NEW INFRASTRUCTURE AT AIRPORTS

The ACSA technical manuals contain project specifications for the design, construction, commissioning and certification of new terminal buildings, retail centres and office buildings in compliance with the requirements set out for green star ratings and the particular credits required. Certain credits are targeted based on what is key to ACSA's business focus, convenience and strategic intention in design and construction of new buildings for the green building credits to achieve 4, 5 and 6-star ratings. These expectations are converted into six categories for ACSA project execution: [3]

- **General Requirements (GR):** This section outlines the principles and requirements that apply to all sustainability requirements for the project regardless of the targeted green star rating chosen.
- **Technologies (T):** This section contains all the technologies that must be implemented in the project to achieve the targeted green star rating.
- **Design Features (DF):** This section includes all the design features that must be included for the project's design and construction to achieve the targeted green star rating.
- **Standards Compliance (SC):** This section lists the standards that the project must comply with during the various project stages to achieve the targeted green star rating.
- **Construction Requirements (CR):** This section provides all the requirements that must be adhered to during the construction stage of the project for the targeted green star rating of which acceptable records must be kept.

- **Project Requirements (PR):** This section has all other requirements that are not covered in the above sections such as professionals that must be appointed together with their duties in the project, modelling, simulations, calculations, reports, strategies, management plans that must be done, surveys, design reviews and other requirements that must be completed to achieve the targeted green star rating.

The information given in all the sections above, except for the GR, are designed to be cumulative, i.e., to achieve a 5-star green rating, the 4-star green rating requirements must be included, and additional requirements listed under the 5-star green rating must be implemented. The specifications given can be used in a project's scope of works. Due to the length and extensive detail given in the technical manuals written in project specification language, there is a quick reference tool provided in the form of a one-pager for executive decision-making enabling executives to view the various requirements for the tiers of green star rating at a summary level to determine which green star rating is to be targeted for a project to be undertaken. This executive decision-making tool can be referred to before Front End Loading (FEL) stages (business planning); namely FEL 01 (conceptual), FEL 02 (pre-feasibility) and also FEL 03 (feasibility) stages of the project [3].

The one-pager executive decision-making tool lists in summarised form the requirements for projects which include base requirements that all projects in ACSA must comply with regardless of green star rating being targeted or not. Additional requirements are given to meet a 4-star rating, 5-star rating and 6-star rating, all requirements being cumulative, i.e. to get to a 4-star rating, one must comply with base requirements and four star rating requirements, to get to a 5-star rating, one must comply with the base requirements, 4-star rating requirements and those requirements listed for the 5-star rating requirements, and so on. The intention is that executive managers consult this tool to review how achievable the green star requirements are in the context of the project's budget constraints, risks, business imperatives and focus areas enabling them to choose the most suitable green star rating. The executive decision-making tool can also be used as a summary in the project briefs and when developed into the project's scope of works, the detailed sections in the technical manual can be used. The credits chosen to be included in each of the various infrastructure types, i.e. terminal, office or retail building, follows [3].

4. RATIONALE FOR THE SELECTION OF CREDITS TO MAKE UP THE GREEN STAR RATINGS FOR THE NEW AIRPORT INFRASTRUCTURE

The business imperatives that played a role in the selection of the credits to be targeted for the 4-star, 5-star and 6-star rated green buildings are discussed; the rationale used when targeting the number of credits with the range given for a 4-star, 5-star and 6-star rating is given, and the credits that are most targeted, as well as those limited or ignored due to lack of focus of the business in those areas, are listed in the followings sections.

4.1 Business Imperatives

One of the most important steps in targeting a green star rating is the selection of the combination of credits that will give points needed to meet the requirements for the green star rating intended (Table 1). In most cases the selection of credits that give the points contributes to the financial implications associated with the green star rating in such a way that there can be negligible excess cost if planned carefully. More importantly, these elements can reduce operational and maintenance costs making for an attractive business case. The credits in each of the green star frameworks (4-, 5- and 6-star green ratings) are chosen based on the following ACSA business principles: [3]

- Savings in operational cost with preferably low or no extra capital cost and any extra capital costs are offset within the project, e.g., extra capital cost for using passive cooling techniques such as low emissivity glass and insulation result in a lower cooling and heating load and thus a smaller capacity HVAC system, lower capex cost of HVAC, lower electricity cost for operations and potentially lower maintenance cost for a smaller system.
- Supporting of the organisational strategic goals, especially those that are aligned to ACSA's vision for stand-alone airports, reduction in operational cost (running and maintenance costs), Occupational Health and Safety and Asset Information Management imperatives.
- Focus placed on credits that reduce environmental impact, therefore significant weighting of waste management and water and energy consumption.
- Knowledge transfer and operating conditions that are fine tuned for operational efficiency.
- Focus on credits that support the Airports Council International (ACI) Carbon Accreditation [3]

4.2 Green Building Framework Design

The combination of credits targeted have been designed to always give points over the minimum threshold for the targeted green star rating due to the nature of project execution in general, where thoroughness in terms of project documentation and timelines in terms of project duration and loss in communication in design and execution results in certain credits targeted not being able to be awarded as per GBCSA strict rules. For this reason, the green star rating target is designed to aim for at least 4 points above the threshold for the targeted green star rating but not within 5 points of the threshold for the next green star rating as this will mean extra cost and effort for the same green star rating.

4.3 Green Building Credits Targeted and Excluded

In accordance with the business case for green buildings, and in keeping with the ACSA operating environment and business imperatives, the credit categories are prioritised as follows:

- Water and energy credits within these categories have been maximised as they are both high in operational cost and scarce resources in South Africa.
- Waste management credits within the materials category have also been targeted towards social responsibility and looming legislation of reduced waste to landfill by 2025 (Western Cape) with penalties for non-compliance and is the direction that most of the world is most probably headed.
- Credits throughout the categories that embed ease of maintenance, operations and management of infrastructure, health and safety best practices, project management and construction management are maximised for a good foundation and which facilitate ACSA's vision and its strategic objectives.
- Credits that allow for implementation considering the highly regulated environment that ACSA complies with as well as that consider the known market capabilities (local and international, i.e., South African marketplace and environmental context).

The following credits have been intentionally limited due to their lack of support of the business and operating environment of ACSA:

- Credits on boiler and generator emissions in the emissions category have been avoided due to airports never using industrial boilers.
- Credits including transport have been excluded as these are typically not considered per building, but rather as an airport planning exercise and in response to demand and commercial opportunity.
- Credits with respect to using recycled materials for building and furnishing, design for disassembly, dematerialisation, etc. have been avoided due to the risk of lifecycle longevity with respect to structural integrity, maintenance requirements and market capability to deliver design concepts and products which may cause time delays as well as compromise Airport Service Quality Ratings (ASQ).
- Credits pertaining to land use and ecology have been largely avoided due to the applicability of these credits from project to project, and because they require special conditions to be at play such as soil contamination before the start of the project, greenfield development, etc. These credits can be revisited for consideration if the conditions are applicable.
- Innovative strategy credits have been excluded to divorce the dependency on them to make up the credits needed for the targeted green star rating as these innovation points are awarded solely on the discretion of Green Buildings Council South Africa.

5. KEY TECHNOLOGIES, DESIGN FEATURES, STANDARDS FOR COMPLIANCE, CONSTRUCTION AND PROJECT REQUIREMENTS FOR AIRPORTS' GREEN STAR RATING

The technical manuals written by the GBCSA provide criteria to be met for each of the nine categories described, however, they do not stipulate the technologies, engineering design features and interventions to be adopted that would allow a project to meet the criteria. The three technical manuals drafted for ACSA give the preferential selection of credits, technologies, design features, standards for compliance, construction requirements and project requirements to be met for each green star rating. To ensure environmental sustainability even when a green star rating is not targeted for a project, certain general requirements and base requirements must be met for adoption of technologies, design features, standards for compliance, construction and project requirements, and must be adhered to for all ACSA projects.

The requirements are contained in three technical manuals for green buildings as follows:

- Technical Manual for Green Star Rated New Terminal Buildings [3]
- Technical Manual for Green Star Rated New Office Buildings [5]
- Technical Manual for Green Star Rated New Retail Centres [6]

Table 2 gives the general requirements for new infrastructure projects in ACSA, regardless of whether a green star rating is targeted or not. Table 3 to Table 17 contain a summary of the key elements of the technologies, design features, standards for compliance, construction requirements and project requirements for new terminal buildings, office buildings and retail centres for 4-star, 5-star and 6-star green buildings certification. Table 3 to Table 7 cover new terminal buildings, Table 8 to Table 12 cover office buildings, and Table 13 to Table 17 cover new retail centres.

Table 2: General Requirements Ensuring Minimum Considerations for the Environment for all New Infrastructure [3][5][6]

General Requirements for all New Infrastructure Projects at ACSA Airports	
<ul style="list-style-type: none"> • Design for cost effectiveness and convenience • Water, working fluids and electrical reticulation to be designed cost effectively to allow for sub-metering and connection to SCADA and BMS systems. • Water, working fluids and electrical reticulation designs must consider ease of maintainability, modularisation, cost effective disassembly, isolation and alternative supply for reduction of operational disruptions. 	
<ul style="list-style-type: none"> • Engineering handover and asset information management (AIM) • Handover documents must be complete, containing original equipment manufacturer (OEM) specifications, as-built drawings, design documents, commissioning results, operations and maintenance (O&M) manuals, user guides, spares supply and inventory. • All maintainable assets to be captured on the AIM database containing asset tags and capturing of all maintenance and technical specifications for each maintainable asset. 	
<ul style="list-style-type: none"> • Knowledge management (KM) • Knowledge transfer must be for all disciplines of the project (engineering, operational, maintenance, costing, market research, project management) and for all phases of the project (design, construction, commissioning, start-up and handover) for at least two people at ACSA per project discipline. • Information management system must be created and maintained during the project to be handed over on an electronic platform that contains all project history, revisions of drawings, meeting minutes, cost revisions, engineering sign offs and certifications, records of interactions with all project parties for the purposes of achieving project deliverables. 	
<ul style="list-style-type: none"> • Tenant lease agreement extracts to preserve the green star rating standard – where shell and core fitouts are part of the project, the appointed green building accredited professional must ensure that the fitout requirements according to the GBCSA targeted green star rating are documented and submitted for enforcement. 	
<ul style="list-style-type: none"> • The appointed green building accredited professional is responsible to ensure that all team members during all phases of the project (design, construction, commissioning and handover – including FEL 03 if appointed at this stage) are aware of the requirements for the green star rating and timeously execute the documentation requirements. 	

Table 3: Requirements for Airport Green star Rated Terminal Buildings: Technology Requirements [7]

Base technologies	<ul style="list-style-type: none"> Standards and guidelines for energy efficiency [4] Power factor correction Air-cooled chillers Dual flush ablutions (3 L and 6 L per flush) Low flow taps, sensor activated (max 3 L/min) Low flow shower heads (max 6 L/min)
4-star rating technologies	<ul style="list-style-type: none"> Paints to meet specific volatile organic compound (VOC) limits Reduction in greenhouse gas emissions by 20 % through alternative energy sources Automated smart energy metering for tenants Maximum electrical demand reduction by 10 %, using pre-programmed load curtailment programmes, electronically controlled. Buffer storage tanks for chilled water storage, lighting circuit switching techniques, daylight harvesting, low emissivity glazing and heat deflective paint to be adopted to reduce peak demand for cooling Closed loop geothermal heat sink to be adopted in place of cooling towers Waterless urinals Rainwater harvesting for irrigation, washing motor vehicles and other second-class water purposes. Active leak detection system for potable water reticulation Collection and use of stormwater for irrigation and designing xeriscape gardens Adoption of methods such as trenches, basins, porous pavements, filter strips, grass swales, media filters, detention ponds, grease and litter traps, hydrocarbon detention, etc. for the management of stormwater and the reduction of total suspended solids (TSS) by 80 % for the run-off volume for rainfall events up to a 1-in-2-year storm. Refrigerants and fire suppression gases to have a zero-ozone depletion potential (ODP)
5-star rating technologies	<ul style="list-style-type: none"> Adhesives and sealants to meet specific VOC limits Total reduction in greenhouse gas emissions by 35 % through alternative energy sources Automated smart metering strategy to include thermal energy meters Reduction in maximum electrical demand through the adoption of ice storage tanks for air conditioning systems Re-use water used for washing of motor vehicles Flush ablutions with grey water or re-used water
6-star rating technologies	<ul style="list-style-type: none"> Daylight glare control systems eliminating 95 % of all direct sun penetration, with blinds/screens having a visual light transmittance (VLT) of < 10 % Carpets and floor coverings to meet specific VOC limits Total reduction in greenhouse gas emissions by 60 % through alternative energy sources and carbon offsetting plants Total reduction in maximum electrical demand by 20 % through making use of waste heat from alternative energy plants to power absorption chillers Where potable water is used to flush ablutions, adopt solenoid control valves for automatic shut off when area is not in use All refrigerants to have a global warming potential (GWP) of 10 or less

Table 4: Requirements For Airport Green Star Rated Terminal Buildings: Design Feature Requirements [7]

Base design features	<ul style="list-style-type: none"> Building management system (BMS) Standards and guidelines for energy efficiency [4]
4-star rating design features	<ul style="list-style-type: none"> Display of sustainability features of the building on an electronic screen in waiting areas, entrances, exhibition areas, etc. Design for maintainability and performing design reviews Lighting is zoned appropriately and controlled according to demand Adoption of roofing, paving and building materials (external hardscape) must have a solar reflectance index (SRI) greater than or equal to 29 and for pitched roof areas less than or equal to 10 degrees, the SRI must be greater than or equal to 78

5-star rating design features	<ul style="list-style-type: none"> • Design of HVAC system must ensure humidity control of the space at 60 % RH and in the supply ducting 80 % RH • Reduce sewer outflow from the development during operations by 30 %
6-star rating design features	<ul style="list-style-type: none"> • Reduce sewer outflow from the development during operations by 50 % through employing blackwater treatment to recirculate treated water in a closed loop system to ablutions

Table 5: Requirements for Airport Green Star Rated Terminal Buildings: Standards for Compliance [7]

Base standards for compliance	<ul style="list-style-type: none"> • Occupational Health and Safety Act (Act 85 of 1993) • Construction regulations, 2014 – Guidelines GN 489 in Government Gazette 40883, dated 2 June 2017 • Regulations for hazardous chemical substances GNR 1179 in Government Gazette 16596, dated 25 August 1995 • Environmental regulations for workplaces GNR 2281 in Government Gazette 10988, dated 16 October 1987 • SANS 204 Energy efficiency • SANS 10400 as applicable • NEMA Act 107 of 1998: NEMA Regulations Government Notice R385 of 2006, Listing Notice 1 Government Notice R386 and R387 of 2006 • ACSA ISO 14001 Environmental Management System: T020 001ASOP – Resources roles and responsibilities of stakeholders • ACSA T030 001-T030 002ASOP – Monitoring and auditing • ACSA T050 002-T050 008ASOP – Environmental management
4-star rating standards for compliance	<ul style="list-style-type: none"> • Commissioning according to CIBSE (Chartered Institution of Building Services Engineers) codes • Maximum lighting illuminance level of no more than 80 % of the illumination levels prescribed in SANS 10114-1: 2005 • ASHRAE 55-2004 Acceptability limits (80 % for 98 % of occupied hours) for naturally ventilated spaces • ISO 7730 for mechanically ventilated spaces (PMV levels between -1 and +1) • The acoustic design must ensure that the noise levels are compliant to SANS 10103: 2008 • Lighting illuminance simulation to demonstrate compliance with SANS 10114-1: 2005 illuminance levels
5-star rating standards for compliance	<ul style="list-style-type: none"> • Lighting pollution prevention through targeted design and illuminance levels compliance with CIBSE LG6 Lighting Guide: 1992
6-star rating standards for compliance	<ul style="list-style-type: none"> • ASHRAE 55-2004 Acceptability limits (90 % for 98 % of occupied hours) for naturally ventilated spaces • ISO 7730 for mechanically ventilated spaces (PMV levels between -0.5 and +0.5)

Table 6: Requirements for Airport Green Star Rated Terminal Buildings: Construction Requirements [7]

Base construction requirements	<ul style="list-style-type: none"> • Environmental management plan (project specific) in accordance with section 3 South Wales, Australia EMS guidelines 2007 or relevant sections of the Provincial Government of the Western Cape EMP Guidelines 2005
4-star rating construction requirements	<ul style="list-style-type: none"> • 1. Construction waste management to recycle 30 % of waste from construction • 2. For brownfield development, the execution of a hazardous materials survey and disposal is required
5-star rating construction requirements	<ul style="list-style-type: none"> • 1. Construction waste management to recycle a total of 50 % of waste from construction
6-star rating construction requirements	<ul style="list-style-type: none"> • 1. Construction waste management to recycle a total of 70 % of waste from construction

Table 7: Requirements for Airport Green Star Rated Terminal Buildings: Project Requirements [7]

Base project requirements	<ul style="list-style-type: none"> • Design and as-built drawings, short reports and schematics of all technologies and design features • Operations and maintenance manuals of all systems and design features • Commissioning of all systems and features to be given upon handover
4-star rating project requirements	<ul style="list-style-type: none"> • Life cycle costing according to ISO 15686-5:2008 performed • 12-month building tuning programme • Appointment of a green star accredited professional (AP) • Issue a building users guide • Appointment of an independent commissioning agent • Energy modelling required demonstrating reduced carbon emissions • Adoption of an automated metering strategy • Adoption of an operational waste recycling and management plan • Appointment of a professional natural scientist
5-star rating project requirements	<ul style="list-style-type: none"> • Contractors and sub-contractors to have ISO 14001 certificate
6-star rating project requirements	None for the selected credits for 6-star rated terminal buildings

Table 8: Requirements for Airport Green Star Rated Office Buildings: Technology Requirements [8]

Base technologies	<ul style="list-style-type: none"> • Standards and guidelines for energy efficiency [4] • Power factor correction • Air-cooled chillers • Dual flush ablutions (3 L and 6 L per flush) • Low flow taps, sensor activated (max 3 L/min) • Low flow shower heads (max 6 L/min)
4-star rating technologies	<ul style="list-style-type: none"> • Paints to meet specific volatile organic compound (VOC) limits • Reduction in greenhouse gas emissions by 20 % through alternative energy sources • Automated smart energy metering for tenants • Closed loop geothermal heat sink to be adopted in place of cooling towers or if this is not possible with designs, adoption of heat recovery from the chiller's condenser to be used for water heating needs as well as recovery of condensate from air handling units for re-use as make-up water for cooling towers • Waterless urinals • Rainwater harvesting for irrigation, washing motor vehicles and other second-class water purposes • Active leak detection system for potable water reticulation • Collection and use of stormwater for irrigation and designing xeriscape gardens • Adoption of methods such as trenches, basins, porous pavements, filter strips, grass swales, media filters, detention ponds, grease and litter traps, hydrocarbon detention, etc. for the management of stormwater and the reduction of total suspended solids (TSS) by 80 % for the run-off volume for rainfall events up to a 1-in-2-year storm • All refrigerants and fire suppression systems to have a "0" ODP • All insulants to have a "0" ODP
5-star rating technologies	<ul style="list-style-type: none"> • Adhesives and sealants to meet specific VOC limits • Total reduction in greenhouse gas emissions by 35 % through alternative energy sources • Flush ablutions with grey water/re-used water • Reduction of potable water demand by 50 % through use of closed loop geothermal heat sinks or air-cooled chillers • Daylight glare control is reduced by using fixed shading devices (overhangs, louvres, etc.) and automated blinds/screens to be adjusted that will reduce direct sun at desk-height for 80 % of standard working hours • Composite wood products used in the project (particleboard, plywood, veneer, MDF and decorative overlaid wood panels) must have zero or minimal formaldehyde emissions in compliance with specific values

6-star rating technologies	<ul style="list-style-type: none"> • Installation of a daylight glare control system that eliminates 95 % of all direct sun penetration, blinds/screens to have a visual light transmittance of < 10 % and can be controlled by occupants • Carpets and floor coverings used in the building and facilities must meet specific VOC limits • Total reduction in greenhouse gas emissions by 60 % through alternative energy sources and carbon offsetting plants • Borehole water use for non-potable water demand • Where potable water is used to flush ablutions, adopt solenoid control valves for automatic shut off when area is not in use • Water based heat rejection systems prohibited • The run-off volume resulting from one day of rainfall that is equaled or exceeded on average three times per year, is either captured and re-used onsite or infiltrated within the site; litter, oil and grease are trapped at source • No water-based evaporative cooling systems • Refrigerant leak detection system and refrigerant recovery system to be installed on HVAC system
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Table 9: Requirements for Airport Green Star Rated Office Buildings: Design Feature Requirements [8]

Base design features	<ul style="list-style-type: none"> • Building management system (BMS) • Standards and guidelines for energy efficiency [4] • Tobacco smoke avoidance in designs such that no indoor spaces be provided for the purposes of smoking
4-star rating design features	<ul style="list-style-type: none"> • For 95 % of the usable area, lighting power densities of 3.0 W/m² per 100 lux at 720 mm above finished floor level (FFL) with default maintenance factor of 0.8 • Lighting is zoned appropriately and controlled according to demand • Reduce sewerage outflow by 30 % • 30 % of the usable area must have a measured daylight factor of not less than 2 % at desk height level (720 mm) under a uniform design sky
5-star rating design features	<ul style="list-style-type: none"> • Design of HVAC system must ensure humidity control of the space at 60 % RH and in the supply ducting 80 % RH • For 95 % of the usable area, lighting power densities of 2 W/m² per 100 lux at 720 mm above FFL with default maintenance factor of 0.8 • The development does not increase (pre-development) peak stormwater flows for rainfall events of up to a 1-in-2-year storm; litter, oil and grease trapped at source • Dedicated tenant exhaust riser to remove indoor pollutants from print and copy areas • Noise levels to be 40 dB(A) eq for general office space and 45 dB(A) eq for open plan space (> 50 m²), acoustic design, report and survey from acoustician
6-star rating design features	<ul style="list-style-type: none"> • For 95 % of the usable area, lighting power densities of 1.5 W/m² per 100 lux at 720 mm above FFL with default maintenance factor of 0.8

Table 10: Requirements for Airport Green Star Rated Office Buildings: Standards for Compliance [8]

Base standards for compliance	<ul style="list-style-type: none"> Occupational Health and Safety Act (Act 85 of 1993) Construction regulations, 2014 – Guidelines GN 489 in Government Gazette 40883, dated 2 June 2017 Regulations for hazardous chemical substances GNR 1179 in Government Gazette 16596, dated 25 August 1995 Environmental regulations for workplaces GNR 2281 in Government Gazette 10988, dated 16 October 1987 SANS 204 Energy efficiency SANS 10400 as applicable NEMA Act 107 of 1998: NEMA Regulations Government Notice R385 of 2006, Listing Notice 1 Government Notice R386 and R387 of 2006 ACSA ISO 14001 Environmental Management System: T020 001ASOP – Resources roles and responsibilities of stakeholders ACSA T030 001-T030 002ASOP – Monitoring and auditing ACSA T050 002-T050 008ASOP – Environmental management
4-star rating standards for compliance	<ul style="list-style-type: none"> Maximum lighting illuminance level of no more than 80 % of the illumination levels prescribed in SANS 10114-1: 2005 Compliance with ASHRAE 55-2004 Acceptability limits (80 % for 98 % of occupied hours) for naturally ventilated spaces and ISO 7730 for mechanically ventilated spaces (PMV levels between -1.5 and +1.5) The acoustic design must ensure that the noise levels are compliant to SANS 10103:2008 Lighting illuminance simulation to demonstrate compliance with SANS 10114-1: 2005 illuminance levels Lighting pollution prevention through targeted design and compliance with illuminance levels in CIBSE LG6 Lighting Guide: 1992
5-star rating standards for compliance	<ul style="list-style-type: none"> Contractors and sub-contractors ISO 14001 certificate
6-star rating standards for compliance	<ul style="list-style-type: none"> Compliance with ASHRAE 55-2004 Acceptability limits (90 % for 98 % of occupied hours) for naturally ventilated spaces and ISO 7730 for mechanically ventilated spaces (PMV levels between -0.5 and +0.5)

Table 11: Requirements for Airport Green Star Rated Office Buildings: Construction Requirements [8]

Base construction requirements	<ul style="list-style-type: none"> Environmental management plan (project specific) in accordance with section 3 South Wales, Australia EMS guidelines 2007 or relevant sections of the Provincial Government of the Western Cape EMP Guidelines 2005
4-star rating construction requirements	<ul style="list-style-type: none"> Construction waste management to recycle 30 % of waste from construction For brownfield development, the execution of a hazardous materials survey and disposal is required
5-star rating construction requirements	<ul style="list-style-type: none"> Construction waste management to recycle a total of 50 % of waste from construction
6-star rating construction requirements	<ul style="list-style-type: none"> Construction waste management to recycle a total of 70 % of waste from construction

Table 12: Requirements for Airport Green Star Rated Office Buildings: Project Requirements [8]

Base project requirements	<ul style="list-style-type: none"> • Design and as-built drawings, short reports and schematics of all technologies and design features • Operations and maintenance manuals of all systems and design features • Commissioning of all systems and features to be given upon handover
4-star rating project requirements	<ul style="list-style-type: none"> • Energy modelling required demonstrating reduced carbon emissions • Adoption of an automated metering strategy • Adoption of an operational waste recycling and management plan • Appointment of a professional natural scientist
5-star rating project requirements	None for the selected credits for 5-star rated office buildings
6-star rating project requirements	None for the selected credits for 6-star rated office buildings

Table 13: Requirements for Airport Green Star Rated Retail Centres: Technology Requirements [9]

Base technologies	<ul style="list-style-type: none"> • Standards and guidelines for energy efficiency [4] • Power factor correction to be done for establishments of electrical demand 1 MW or 10 % of the airport's load, whichever is the smaller • Air-cooled chillers • Dual flush ablutions (3 L and 6 L per flush) • Low flow taps, sensor activated (max 3 L/min) • Low flow shower heads (max 6 L/min)
4-star rating technologies	<ul style="list-style-type: none"> • Paints to meet specific VOC limits • Reduction in greenhouse gas emissions by 20 % through alternative energy sources • Automated electrical metering strategy that includes smart meters for all users in the building 100 kVA or more • Maximum electrical demand reduction by 10 %, using pre-programmed load curtailment programmes, electronically controlled. Buffer storage tanks for chilled water storage, lighting circuit switching techniques, daylight harvesting, low emissivity glazing and heat deflective paint to be adopted to reduce peak demand for cooling • Closed loop geothermal heat sink to be adopted in place of cooling towers • Waterless urinals • Rainwater harvesting for irrigation, washing motor vehicles and other second-class water purposes • Active leak detection system for potable water reticulation • Collection and use of stormwater for irrigation and designing xeriscape gardens • Adoption of methods such as trenches, basins, porous pavements, filter strips, grass swales, media filters, detention ponds, grease and litter traps, hydrocarbon detention, etc. for the management of stormwater and the reduction of total suspended solids (TSS) by 80 % for the run-off volume for rainfall events up to a 1-in-2-year storm • All refrigerants and fire suppression systems to have a "0" ODP
5-star rating technologies	<ul style="list-style-type: none"> • Adhesives and sealants to meet specific VOC limits • Total reduction in greenhouse gas emissions by 35 % through alternative energy sources • Automated smart metering strategy to include thermal energy meters • Reduction of maximum electrical demand by a further 10 % making use of ice storage tanks that will allow for a relatively flat HVAC demand • Flush ablutions with grey water or re-used water • All insulants to have a "0" ODP • Reduction of potable water demand by 50% through use of closed loop geothermal heat sinks or air-cooled chillers • Composite wood products used in the project (particleboard, plywood, veneer, MDF and decorative overlaid wood panels) must have zero or minimal formaldehyde emissions in compliance with specific values • Metering thermal energy users (10 kW or more) with connection to the BMS system

6-star rating technologies	<ul style="list-style-type: none"> • Total reduction in greenhouse gas emissions by 60 % through alternative energy sources and carbon offsetting plants • Total reduction in maximum electrical demand by 20 % through additionally making use of waste heat from alternative energy plants to power absorption chillers • Borehole water use for non-potable water demand • Where potable water is used to flush ablutions, adopt solenoid control valves for automatic shut off when area is not in use • Water based heat rejection systems prohibited • Refrigerant leak detection system and refrigerant recovery system to be installed on HVAC system • All refrigerants adopted to have a Global Warming Potential (GWP 100) of 10 or less
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Table 14: Requirements for Airport Green Star Rated Retail Centres: Design Feature Requirements [9]

Base design features	<ul style="list-style-type: none"> • Building management system • Standards and guidelines for energy efficiency [4]
4-star rating design features	<ul style="list-style-type: none"> • Adoption of a waste and recycling management plan that seeks to reduce the operational waste generated and recycle maximum waste from all users (including tenants), setting waste targets and making provision for facilities supporting separation at source • The building owner/manager must ensure that no less than 80 % of the rentable area (as per SAPOA definition) is committed to a tenancy lease agreement that requires the tenants to monitor and report quarterly on electrical energy consumption, water consumption, waste recycling, having submitted a plan for each of these at the beginning of the lease, together with a green procurement policy to procure environmentally friendly consumables • The acoustic design and report must ensure that the noise levels do not exceed 55 dBA in full operation • Provision must be made for respite and connection to nature for staff and visitors, minimum of 50 m² and 0.1 % of the retail GFA (gross floor area) must be set aside as a rest area that has direct physical and visual connection to the natural environment • Energy modelling required demonstrating reduced carbon emissions • Adoption of an “automated metering strategy” that meters all major water users and tenants connected to a smart metering system that can be used for billing, historical data analysis and live tracking of water losses through water zonal meters as well as being integrated to the active potable water leak detection system • Adoption of an operational waste recycling and management plan • Appointment of a professional natural scientist • Adoption of roofing, paving and building materials (external hardscape) must have a solar reflectance index (SRI) greater than or equal to 29 and for pitched roof areas less than or equal to 10 degrees, the SRI must be greater than or equal to 78 • Reduce sewerage outflow by 30 %
5-star rating design features	<ul style="list-style-type: none"> • Design of HVAC system must ensure humidity control of the space at 60 % RH and in the supply ducting 80 % RH • Kitchen exhaust points must be located not closer than 1.0m to a neighbouring usable space or walkway, or a fresh air intake of that development or another development
6-star rating design features	None for the selected credits for 6-star rated retail centres

Table 15: Requirements for Airport Green Star Rated Retail Centres: Standards for Compliance [9]

Base standards for compliance	<ul style="list-style-type: none"> • Occupational Health and Safety Act (Act 85 of 1993) • Construction regulations, 2014 – Guidelines GN 489 in Government Gazette 40883, dated 2 June 2017 • Regulations for hazardous chemical substances GNR 1179 in Government Gazette 16596, dated 25 August 1995 • Environmental regulations for workplaces GNR 2281 in Government Gazette 10988, dated 16 October 1987 • SANS 204 Energy efficiency • SANS 10400 as applicable • NEMA Act 107 of 1998: NEMA Regulations Government Notice R385 of 2006, Listing Notice 1 Government Notice R386 and R387 of 2006 • ACSA ISO 14001 Environmental Management System: T020 001ASOP – Resources roles and responsibilities of stakeholders • ACSA T030 001-T030 002ASOP – Monitoring and auditing • ACSA T050 002-T050 008ASOP – Environmental management
4-star rating standards for compliance	<ul style="list-style-type: none"> • ASHRAE 55-2004 Acceptability limits (80% for 98% of occupied hours) for naturally ventilated spaces • ISO 7730 for mechanically ventilated spaces (PMV levels between -1.5 and +1.5) • Lighting illuminance simulation to demonstrate compliance with SANS 10114-1: 2005 illuminance levels • Lighting pollution prevention through targeted design and illuminance levels compliance with CIBSE LG6 Lighting Guide: 1992
5-star rating standards for compliance	<ul style="list-style-type: none"> • Contractors and sub-contractors ISO 14001 certificate • SANS 1850: 2003 Design and manufacture of commercial kitchen extraction, ASHRAE Handbook 2007: HVAC Application, Chapter 31 Kitchen ventilation
6-star rating standards for compliance	<ul style="list-style-type: none"> • ASHRAE 55-2004 Acceptability limits (90% for 98% of occupied hours) for naturally ventilated spaces • ISO 7730 for mechanically ventilated spaces (PMV levels between -0.5 and +0.5)

Table 16: Requirements for Airport Green Star Rated Retail Centres: Construction Requirements [9]

Base construction requirements	<ul style="list-style-type: none"> • Environmental management plan (project specific) in accordance with section 3 South Wales, Australia EMS guidelines 2007 or relevant sections of the Provincial Government of the Western Cape EMP Guidelines 2005
4-star rating construction requirements	<ul style="list-style-type: none"> • Construction waste management to recycle 30 % of waste from construction • For brownfield development, the execution of a hazardous materials survey and disposal is required
5-star rating construction requirements	<ul style="list-style-type: none"> • Construction waste management to recycle a total of 50 % of waste from construction
6-star rating construction requirements	<ul style="list-style-type: none"> • Construction waste management to recycle a total of 70 % of waste from construction

Table 17: Requirements for Airport Green Star Rated Retail Centres: Project Requirements [9]	
Base project requirements	<ul style="list-style-type: none"> • Design and as-built drawings, short reports and schematics of all technologies and design features • Operations and maintenance manuals of all systems and design features • Commissioning of all systems and features to be given upon handover
4-star rating project requirements	<ul style="list-style-type: none"> • Construction waste management to recycle 30 % of waste from construction • For brownfield development, the execution of a hazardous materials survey and disposal is required
5-star rating project requirements	None for the selected credits for 5-star rated retail centres
6-star rating project requirements	None for the selected credits for 6-star rated retail centres

The requirements contained in Table 3 to Table 17 is highly summarised and correspond to credits that amount to the number of points for a 4-star, 5-star and 6-star green ratings.

6. PROCESS TO IMPLEMENT GREEN BUILDINGS FOR NEW INFRASTRUCTURE AT AIRPORTS

In the process flow of ACSA's project management plan, five levels or stages are identified, i.e., FEL 01 to FEL 05 after business planning takes place to identify all the initiatives that need to take place (Pre-Level FEL01). The execution of sustainability (and green buildings) in each of the stages within the project management process flow can be seen in Fig. 3.

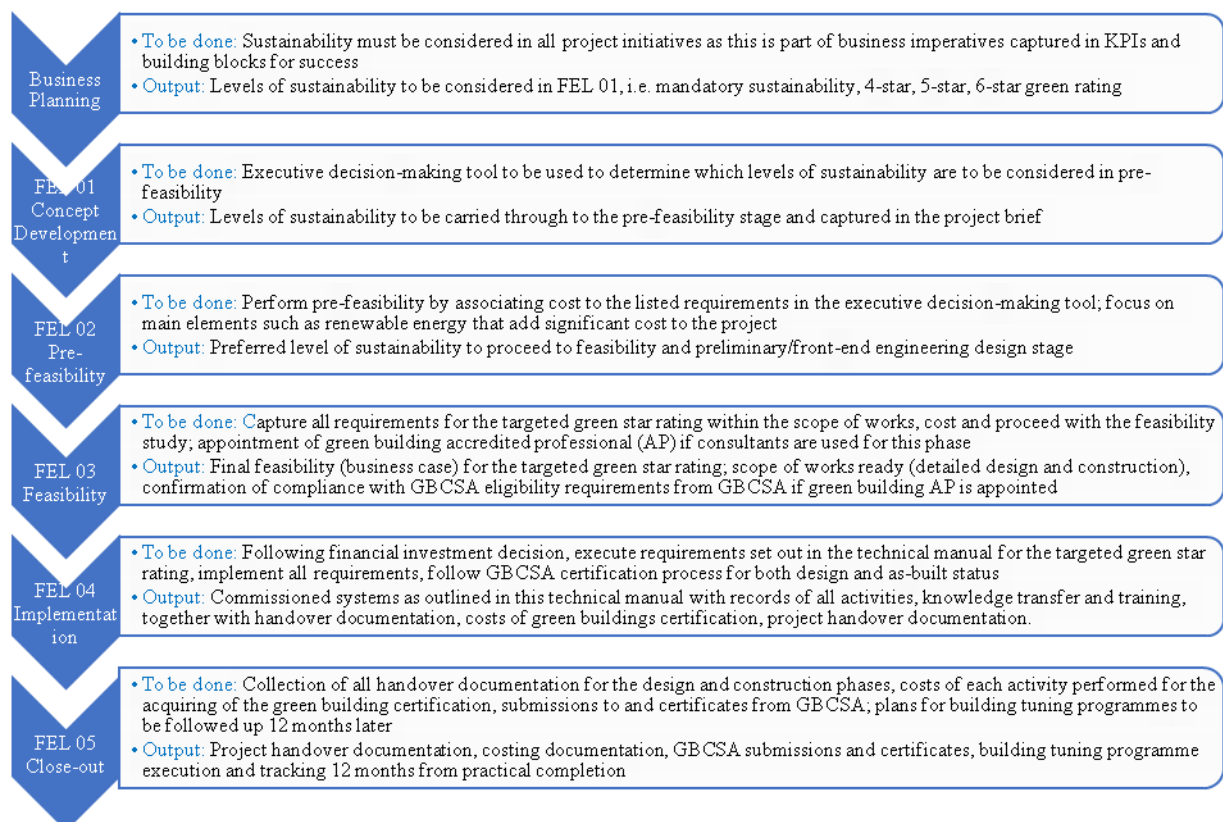


Figure 3: Project Management Process Flow.

During **business planning**, the company's business imperatives, which are largely guided by the company's vision, strategic objectives and business KPIs, must be incorporated into the high-level definition of targeted initiatives (soon to become projects). At this level, environmental sustainability must be taken into account due to environmental sustainability being part of the company's vision.

From **FEL 01** stage where **concept development** starts, the level of sustainability targeted must be considered and guided by the strategic objective of attaining carbon neutrality in energy consumption; the availability, cost and risks to the business of energy and water supply; and the legislative requirements around waste management over the project lifecycle. The minimum requirements for energy efficiency in all projects are contained in the Standards and Guidelines for Energy Efficiency which is a company policy document in ACSA

The targeted green star rating decision should be taken at Level **FEL 02 (pre-feasibility)** in order to determine the cost and benefit using high level trade-offs between water, electricity savings (and waste generation where data is available) and capital costs.

For **FEL 03 (feasibility)**, the detailed clauses contained in the technical manual must be used to define the scope of works for the targeted green star rating, from which a project specific capital cost can be drawn up together with operational cost savings, from which a business case can be formed.

The Green Star Rating for ACSA is targeted for both "design" and "as-built" status. Once a financial investment decision (FID) is made to go ahead with the project, registration of the project for the targeted green star rating must commence with Green Building Council of South Africa (GBCSA).

Step 1 in the GBCSA process is checking for eligibility for the targeted green star rating. This can be sought in FEL03. At this point it is advisable to appoint a green building accredited professional (AP), although this can also be done in FEL 04. The project will be checked for compliance with four eligibility requirements, i.e., spatial differentiation, space use, two conditional requirements and timing of certification as follows:

- In the spatial differentiation requirement, the project must be clearly distinct as a free-standing building or an extension of an existing building, i.e., no partial components of projects will qualify.
- The space use requirement determines which GBCSA green star rating tool is applicable.
- The conditional requirements that the project must meet are with respect to the energy category and the land use and ecology category.
- The timing of the certification requirement is that obtaining of the certification (both "design" and "as-built") must be within 24 months of the date of practical completion of the project.

Once the eligibility requirement has been met, the project can then be submitted for the GBCSA certification process (Figure. 2). The relevant documentation must be put together as per the targeted green star rating requirements. Assessment takes about 7 weeks. Should the rating need documentation which could not be found in the first submission, this will activate a second round giving the opportunity to submit the required documentation. Important to note is that there are only two rounds in the green building certification process.

In **FEL 05 (close-out)**, all documentation including O&M manuals, building user guides, training and knowledge transfer records and material, commissioning and technical specifications, manufacturer's data sheets as well as signoffs from each stage gate must be handed over. The costings for the green star rating must be included together with all submissions (and data) to, and received from, GBCSA. The 12-month building tuning programme must be ready (with implementation plan, resourced) and be put into action, tracked and closed out after 12 months with handover documentation submitted. Once this is done, the process is complete.

7. CONCLUSIONS

This paper successfully presented the guidelines for implementing green star rated new terminal buildings, office buildings and retail centres. The guidelines included general requirements, technology requirements, design feature requirements, standards for compliance, construction requirements and project requirements for 4-star, 5-star and 6-star rated green new terminal, office and retail infrastructure. The guidelines were a summary taken from the technical manuals for green buildings prepared for ACSA in accordance with the Green Building Council South Africa (GBCSA). A description of the green star rating frameworks and the rationale used to select the credits that give the green star rating for each type of infrastructure is given. The process to implement the green star rated infrastructure at the airports is outlined showing how carbon emissions are being reduced, and environmental consciousness is being observed. This ensures the efforts to transform the airport sites towards energy efficiency and energy security are sustained.

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